National Bureau of Standards

TECHNICAL NEWS BULLETIN

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Radio Disturbance Warnings

The radio disturbance warning notices broadcast regularly from radio station WWV of the National Bureau of Standards are based on comprehensive observations of radio, ionospheric, solar, and geomagnetic phenomena at stations throughout the world. Applying especially to radio transmission paths over the North Atlantic, such as New York-London and Washington-Berlin, the warnings give advance notice of disturbances affecting high-frequency radio transmissions. The warnings are given in code following the time announcements at 19 and 49 minutes past each hour. A series of N's signifies that radio propagation conditions are normal, a series of U's that they are unstable, and a series of W's that they are disturbed or are expected to become so within 12 hours.

The problem for the warning service is to identify a disturbance in its early stages. The earlier in its development a storm is identified as such, the more forewarning will be given by a disturbance notice. The Bureau's warning service maintains a monitoring program on sensitive communication circuits and keeps a close watch on certain types of ionospheric, magnetic, and solar activity that have been found to be closely associated with radio disturbance. Regularly each day at 9:30 a. m. and 4 p. m. local civil time at Washington, D. C., radio conditions are evaluated and the warning notice continued or changed. In exceptional cases, the notice may be changed at any time of day.

Controlled measurements of the ionosphere itself are essential to the warning service. Vertical-incidence soundings are made at a large number of stations throughout the world, and observations near Washington and at nine Canadian points are reported promptly by telephone or radio. Usually disturbances observed at Washington are characterized by reduced critical frequencies and abnormally great virtual heights of the upper ($F2$) reflecting layer. In some severe disturbances, the electron density of this $F2$ layer will be less than that of the $F1$ layer. Radio disturbances are closely associated with abnormal activity of the earth's magnetic field; no severe radio storms are known to have taken place without a concurrent magnetic storm. The visually recording magnetograph, measuring the variations of the horizontal component of the earth's field, is probably the most important single aid in radio disturbance warning. Since Washington is located in an intermediate geomagnetic latitude, storm variations observed there give a reliable indication of magnetic disturbances throughout the world.

There are two usual ways of judging magnetic activity: by erratic variations and by minimum absolute intensity. The beginning of a geomagnetic disturbance may be indicated by an abrupt increase of intensity followed by irregular intensity variations and then a large decrease of intensity. In some storms the change from quiet conditions to irregular variations is a gradual one. A warning notice "W" issued shortly after the

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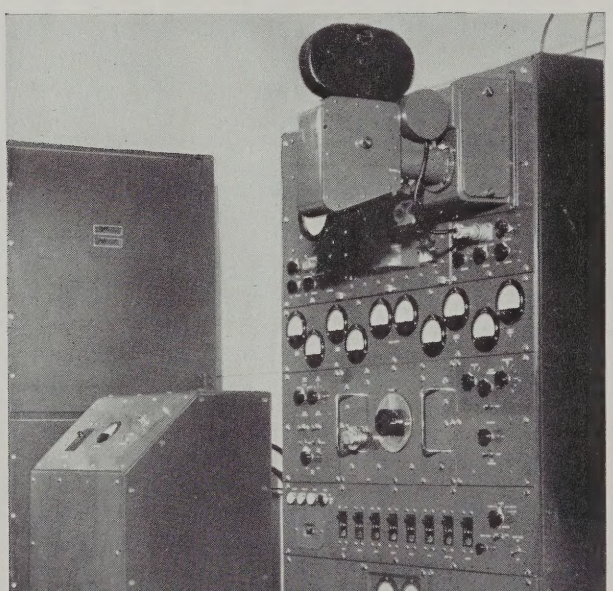
irregular variations have begun should be a forewarning, since radio disturbances usually do not become severe until there has been a considerable decrease in horizontal magnetic intensity. A geomagnetic storm that begins with a sudden large decrease of intensity will give little or no forewarning of the accompanying radio disturbance.

All the observations described so far pertain to abnormal conditions in the earth's atmosphere; they concern the effects of disturbances, not the cause. Although years of observation and study have shown a very close association between solar activity and terrestrial disturbances, it is not certain that the activity seen on the sun has anything directly to do with radio propagation storms. In fact, the most spectacular solar phenomena—the active or eruptive prominences—have no apparent correlation with magnetic and ionospheric upsets. It is known, however, that active regions of the sun's surface are usually facing the earth when terrestrial disturbances begin.

Through a program for systematic observation of the sun, coordinated by the National Bureau of Standards, reports on solar activity arrive daily from nine solar observatories in the United States and Europe. Each active region is judged during the 7-day period from the time it appears at the edge of the sun until the time, as the sun rotates, that it most nearly faces the earth. This information is very useful for interpreting the behavior of the ionosphere—in distinguishing between random fluctuations and a bona fide disturbance. If there is an active solar region approximately opposite the earth, then a deviation from normal radio conditions is more likely to mark the beginning of a significant disturbance. Sudden radio fadeouts, probably an indirect indication of solar flares, are reported from the Bureau's Belvoir station. Although used principally in preparing the weekly disturbance forecasts, this information aids the warning service as well.

With these many and varied reports, the forecasters of the Bureau's warning service continually assess current radio propagation conditions on North Atlantic transmission paths and predict their probable trend. Success in identifying disturbed conditions is limited by the loose definition of average conditions on an average circuit, but some circuits will almost always be subnormal while the "W" is broadcast, and rarely will a large number of circuits experience trouble when the warning notice is "N". True forewarning of a significant disturbance is only possible if the disturbance begins during a monitoring period of the warning center and if the statistically determined relationships between radio propagation and other phenomena are valid, to within small errors, for the given disturbance.



An automatic ionosphere recorder (right), designed by the National Bureau of Standards, is used at the Bureau's Belvoir field station to gather ionospheric data which will aid in predicting radio disturbances.

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U. S. Department of Commerce
Charles Sawyer, *Secretary*
National Bureau of Standards
E. U. Condon, *Director*

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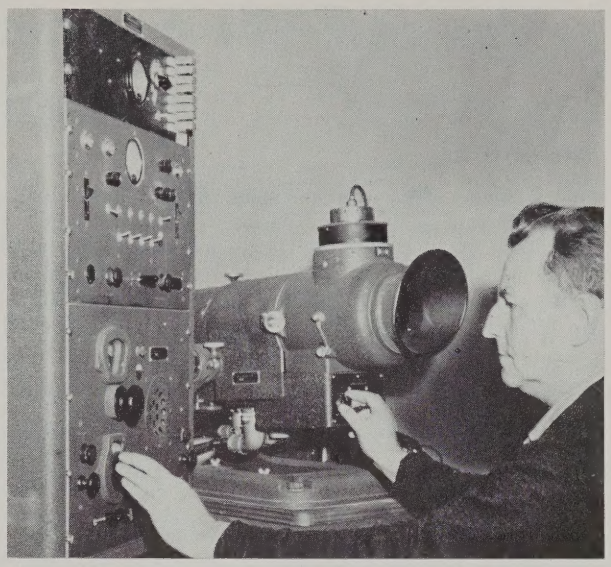
For storms that start abruptly or at a time of day when the warning center has no observers on duty, the warning notice "W" will be first broadcast only after the disturbance has begun. It then serves to identify the poor radio conditions as a propagation disturbance. This information can still be useful to the operators of communications circuits. It tells them that the difficulty is not with their equipment and that the disturbance is not transitory, but will probably last for many hours.

Given a forewarning of a propagation disturbance, a radio operator can take steps to minimize its effect. High priority traffic can be rushed through before the circuit deteriorates; operations requiring assured communications (such as polar flights) can be postponed; and rerouting facilities can be alerted for use until the radio storm has subsided. During the disturbance, communications in some instances may be maintained on a lower frequency than ordinarily employed; if it is a severe storm, the increased absorption low in the ionosphere and the decreased electron density of the reflecting layers will combine to render high frequencies useless. Relaying from station to station over paths less severely affected is then the only way of moving traffic.

In any event, the operator must evaluate the disturbance warnings in the light of his experience with the circuit he is using. Simple point-to-point circuits, especially those operated with high power and directive antennas, will be least affected. Propagation requirements are, however, more exacting for ship-to-shore, airplane-to-ground, and high-speed multi-channel circuits. These differing requirements are recognized by the warning notice category "U", established on November 1, 1949. The warning notice "U" will be given when exacting communication services may expect much more difficulty than ordinary communication links. Such conditions are found most often during the subsiding stage of a major disturbance.

The location of the particular great-circle transmission path with respect to the auroral zone is also important. Paths that touch but do not cross this zone are most sensitive to radio disturbance. Less severely affected are paths that cross the zone at large angles, whereas for circuits in lower latitudes the susceptibility to disturbance decreases as the minimum distance to the auroral zone becomes greater.



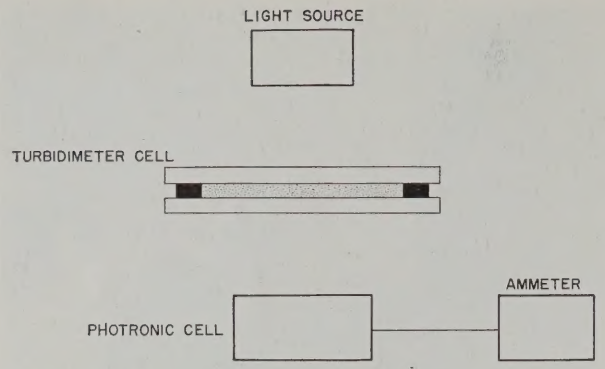
The direction of arrival of radio waves from trans-atlantic stations is measured by the National Bureau of Standards with this instrument. When the observed direction deviates from normal, ionospheric conditions are unsettled.

Disturbances to radio communications depend not only on the magnitude of the changes in upper atmosphere characteristics, but also very strongly on the normal propagation conditions for the circuit involved. The range of usable frequencies for any circuit is limited at the high-frequency end by the maximum usable frequency of the ionospheric reflecting layer and at the other by absorption in the lower ionosphere. Near the maximum of the sunspot cycle, the range of usable frequencies is relatively broad, since the maximum usable frequency is a steep function of sunspot number, while the lower limiting frequency determined by absorption increases only slightly with sunspot number. However, at minimum solar activity the range of usable frequencies is much more restricted. At certain hours, over some transmission paths, sky-wave propagation may be impossible even on a normal day. Thus while nothing less than a "great" storm can interfere with communications when there is a wide choice of usable frequencies, a minor disturbance during periods of low sunspot activity may wipe out communications entirely.

Rapid Determination of the Carbonaceous Residue in Bone Char

A simple, rapid procedure [1] for determination of the carbonaceous residue in bone char has been developed by N. L. Pennington and V. R. Deitz of the National Bureau of Standards. By use of a previously determined calibration curve, the percentage of carbonaceous material in a sample is almost immediately obtained on the basis of a turbidity measurement of the powdered char in an acidified suspension. As measurements can be made in rapid succession by an operator with a minimum of specialized training, the new technique is particularly well suited to routine process control in sugar refineries.

[1] For further technical details, see Rapid determination of the carbonaceous residue in bone char, N. L. Pennington and V. R. Deitz, Proc. Tech. Session on Bone Char, page 32 (1949).



A diagram of a turbidimeter used by the Bureau to determine carbonaceous residue in bone char is shown. The turbidimeter cell consists of two glass plates 8 in. square separated by a 1/16-in. brass plate containing a 5-in. hole. Samples of bone char in suspension are placed in the cell between a light source and a photronic cell connected to a microammeter. A transmittance reading is obtained from the microammeter, and the percentage of carbonaceous matter is determined by a graphical procedure.

Decolorization and purification of raw sugar is accomplished by passing the sugar liquor through one of a number of filters, about 10 feet in diameter and 20 feet deep, containing bone char. As the char becomes exhausted, it is regenerated by heat treatment in a kiln. In this process the extent of oxidation is critical and is indicated by the percentage of carbonaceous residue (usually abbreviated "% Carb") present in the revivified char.

In the past, the % Carb in bone char has been determined by a technique of gravimetric analysis that involves several weighings as well as ignition of the material to constant weight. As these operations are very time-consuming, the National Bureau of Standards undertook to devise a procedure that would be better adapted to routine analysis in the refinery laboratory.

The method developed by the Bureau employs an easily constructed turbidimeter cell that consists of two glass plates 8 inches square separated by a $\frac{1}{16}$-inch brass plate containing a 5-inch hole. The assembly is made watertight by sealing with stopcock grease. Various concentrations of the sample of bone char in suspension, obtained by successive dilutions, are placed in this turbidimeter cell between a light source and a photronic cell connected to a microammeter. For each concentration, the transmittance—that is, the ratio of the intensity of the light transmitted through the suspension to the intensity of that transmitted through distilled water—is obtained from the reading of the microammeter. The % Carb is then readily determined from these data by a simple graphical procedure.

In preparing the bone char suspension, the sample to be analyzed is first ground in an automatic mortar and pestle. The sample is ground until about half passes through a No. 270 sieve, and 10 milliliters of a 1-to-5 solution of hydrochloric acid are then slowly added to 0.2 gram of the sieved sample in a beaker. The resulting mixture is brought to boiling and diluted to 100 milliliters.

Before taking readings, the light source and photronic cell are adjusted so that transmission is 100 percent with distilled water in the turbidimeter cell and so that the microammeter reads zero when all of the light is blocked off. The transmittance, T_1, of the prepared sample of concentration C_1 is then obtained. The cell is next emptied, washed, and wiped dry. The construction of the cell makes this a simple operation. A portion of the remaining original suspension is diluted to twice its volume with distilled water, and the transmittance T_2 is obtained for the new concentration C_2. This procedure is repeated for several more dilutions or until the concentration becomes so small that the transmittance is about unity.

As long as the concentration is sufficiently low, the values obtained in this way obey the relationship $\log 1/T = S \times C$, where S is a constant for each char. In the region under consideration, the plot of $\log 1/T$ as a function of C is linear, and its slope is equal to S. As soon as enough transmittance measurements have been made to give a value for S, the corresponding value of the % Carb is easily obtained by reference to a calibration curve of S versus % Carb.

In plotting the calibration curve, the % Carb is determined for a number of samples in the conventional manner by measuring the loss in weight upon ignition of the acid-washed residue. Although this process is time-consuming, it is required only once for construction of the calibration curve, which can then be used to determine the % Carb of any particular char sample.

In using this procedure two precautions are necessary. First, all samples should be prepared in like manner since wide variations in the original particle size may affect the accuracy of the method. The second precaution consists in careful control of the constancy of the light source.

Turbidimetric measurements are now being widely used for analysis of a variety of substances. Although the accuracy is not always as great as may be realized by more exact procedures, the method is preferred in many instances because of its rapidity. The Bureau's new procedure, which has already been adopted by several refinery laboratories, appears applicable to all bone chars and also to many other carbonaceous adsorbents such as activated carbons. Another possible application, as yet unexplored, is the analysis of the carbonaceous material in coke and coal-like substances in order to determine their burning qualities.

Techniques and data resulting from the Bureau's extensive experience in spectrophotometry have been presented in a new NBS Circular so that users of spectrophotometers can calibrate and maintain their instruments properly, and guard against the errors common in such work. Instruments and methods for use in the ultraviolet, visible, and near-infrared spectral regions are considered. Circular 484, *Spectrophotometry*, is available only from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., at 25 cents a copy.

Reinforcement of Openings in the Stressed Skin of Airplanes

In an ideal airplane the metal covering of the wings and fuselage would be smooth and continuous; in practice, openings must be provided in the stress-carrying skin for maintenance operations and for windows, doors, lights, and retractable landing gear. These holes are often reinforced with metal rings, known as doubler plates, which are riveted to the inner surface of the sheet. The thickness and rigidity of the sheet at the edge of the hole are thus increased. It has not been known how well such a reinforcement approaches the ideal of confining the disturbance in stress flow to the immediate neighborhood of the hole and, at the same time, adding the least weight to the structure. To secure a better understanding of reinforcements and practical improvements in their design, the National Bureau of Standards has carried on an extensive experimental and theoretical investigation sponsored by the Navy's Bureau of Aeronautics.

The work began with an analysis of symmetrical reinforcements around a circular hole in a plate under uniform tension. To reduce the stress concentration with minimum weight increase, it was found that a reinforcement should concentrate most of its mass near the edge of the hole. Such a graduation in the thickness of a reinforcement is not practical from a construction standpoint. Fortunately a flat ring, of the same thickness as the skin and of outer diameter equal to twice the hole diameter, was found to be almost as effective. Consequently, this type of reinforcement was selected for further study.

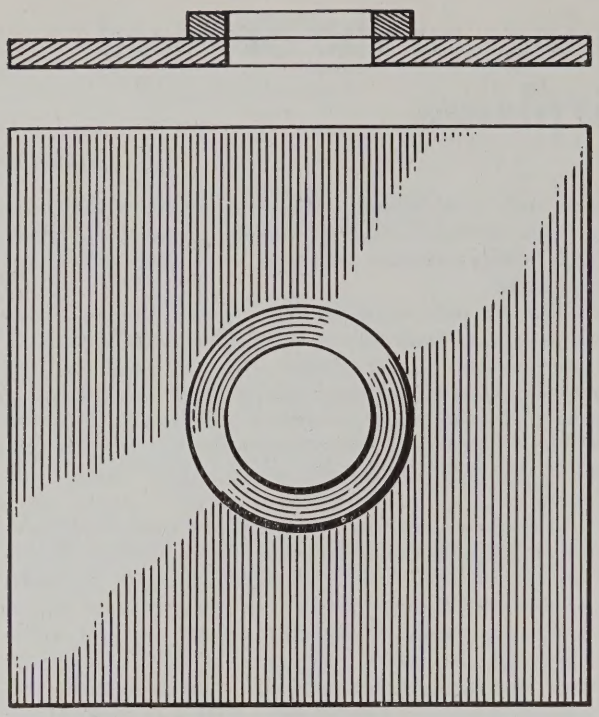
The plane stress theory assumes that the reinforcement is an integral part of the sheet and that the stresses do not vary across the plate thickness. In practice, reinforcing plates are riveted to the stressed skin, and large variations in stress distribution across the thickness may occur. Tensile tests throughout the elastic range were applied to a panel with riveted symmetrical doubler plates of different sizes and rivet arrangements in order to determine the effect of these stress variations on the accuracy of the plane stress analysis. Strain measurements were taken at several positions on both the sheet and the reinforcement. Comparison of the measured strains with those computed from the plane stress theory showed good agreement outside the reinforced area. Measured and computed reinforcement strains agreed best in the case of a reinforcing ring fastened with two consecutive rows of rivets.

In modern aircraft the outer surfaces of wings and fuselages must be kept as smooth as possible to minimize drag so that the airplane can attain higher speeds. For this reason, hole reinforcements are placed on the inner surface only. A panel with an asymmetrical reinforcement was chosen for test to failure, revealing that the principal effect of reinforcing one side of a sheet only is to introduce bending moments that tend to bring the reinforcement into the plane of the sheet. High bending stresses may also occur in the reinforcement itself.

Since the tests of panels with riveted doubler plates indicated that there was an incomplete transfer of load from the sheet to the doubler plate, a tensile test was made of a panel in which the symmetrical reinforcement of the hole was bonded to the sheet with an adhesive. Agreement between experimental results and those computed from the plane stress theory was excellent.

Access holes may be located in the curved surfaces of aircraft, and it is desirable to know the effect of this curvature on the strain distribution around the hole. For that reason, compressive tests were made on curved panels whose radii of curvature varied from 10 inches to infinity (flat sheet). The test data were analyzed in terms of the plane stress theory, neglecting curvature, since no theory for curved sheet with a reinforced circular hole was available. Computed values for strain concentration throughout the elastic region agreed well with those determined experimentally for the unreinforced regions of the panels. In the reinforced regions, however, the strains in the sheet near the hole were higher than the computed strains, whereas those in the reinforcement were lower. This may be traced to the fact that the reinforcements in these tests were attached with only one row of rivets and thus did not function as an integral part of the sheet. Deflection measurements show that reinforcement of the hole does reduce bending in the immediate vicinity of the hole. A reinforcement on one side of the sheet only has a larger moment of inertia about the mid-thickness of the sheet and thus resists bending better than a symmetrical reinforcement of the same total thickness.

Reinforced openings are provided in the metal skin of the modern airplane for maintenance and for windows, doors, and lights. The Bureau has conducted a theoretical and experimental investigation to determine effects of the reinforcements on the strength of the stress-carrying skin.



Typical section of square plate with reinforced circular hole studied theoretically and experimentally as part of a broad Bureau program on strength of aircraft structures.

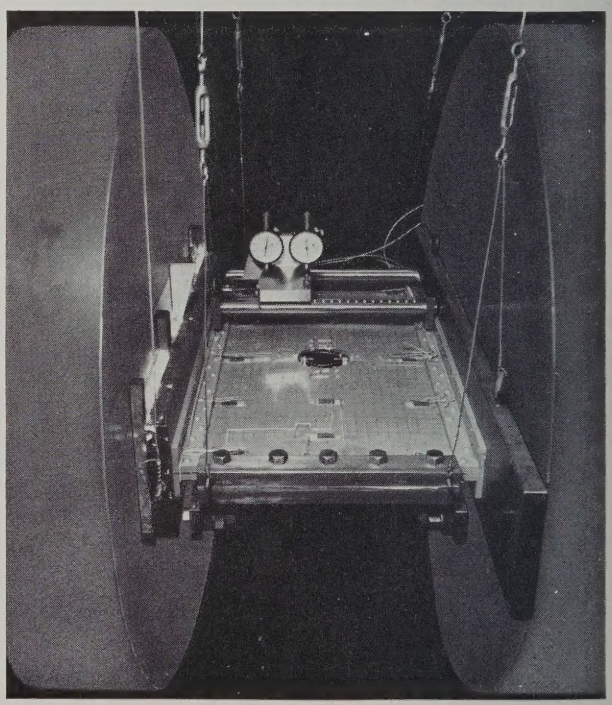
The importance of smooth wing surfaces for high-speed flight makes it desirable to eliminate the surface buckling which occurs when the critical load of a panel is exceeded. The effect of cut-outs on the buckling load has been studied both with and without reinforcement. The compressive buckling load was determined theoretically for six simply supported square plates, three of which had unreinforced central holes of different diameters. Buckling loads for these plates were found to be only slightly lower than the buckling load for an unperforated square plate of uniform thickness. Theoretical elastic buckling loads for square plates with a central hole of diameter one-fourth the length of a side and reinforced with doubler plates are larger by from 55 to 122 percent than those of a plate without a hole. The computations also indicated that the buckling strength of a square plate with a central hole, although dependent on the volume of the reinforcing material, is relatively independent of the shape of the reinforcement.

Since the panels forming the stressed-skin surface of airplanes are subjected to shear loads as well as to compressive loads, the critical shearing stresses of simply supported square plates with a central circular hole, reinforced and unreinforced, were also computed. The calculated elastic critical shearing stresses of plates with reinforced holes were from 20 to 236 percent higher than those for plates without holes. The critical shearing stress of a square plate is lowered by the presence of a central hole but raised by reinforcing the hole; the increase in buckling load is dependent on both the shape and size of the reinforcement.

The need for maintaining aerodynamically smooth surfaces has led to the development of sandwich construction to replace sheet-stringer construction in aircraft. The sandwich plates are made with a relatively thick core of low-density, low-stiffness material such as balsa wood, to which is bonded a thin covering layer of high-stiffness material, such as aluminum alloy sheet. When a sandwich panel is attached to some other member, it may be necessary to transfer the loads from the member to the panel by means of a pin that fits into a reinforced hole in the panel. A theoretical analysis was made to determine the stress distribution in a flat plate near a reinforced circular hole loaded by a pin. The analysis was then checked by comparison with test results on an actual sandwich panel. The results indicate that the theoretical values can be used in the elastic range in design problems involving sandwich construction with pin-loaded cut-outs.

Several general conclusions may be drawn from these investigations of reinforced cut-outs in the stressed-skin surfaces of aircraft:

The reinforcement is more effective in reducing the stress concentration at the hole when it is fastened to the sheet with at least two rows of rivets or bonded to the sheet so that reinforcement and sheet act as an integral unit. If the reinforcements are attached in this way, the plane stress theory can be used in the



Stress distribution around a circular opening was determined experimentally by subjecting typical square plates to compressive loads in the Bureau's horizontal testing machine. Critical shearing stresses were also determined for both reinforced and unreinforced holes in simply supported square plates.

elastic region for computations of the average median surface stresses in the sheet and reinforcement and to predict changes in the hole diameter.

Reinforcement of one side of the sheet only introduces bending moments that tend to bring the reinforcement into the plane of the sheet and may result in bending stresses in the reinforcement of the same order of magnitude as the median fiber stresses. The median fiber strains in the unreinforced regions of cylindrically curved panels of moderate curvature can be determined with sufficient accuracy from the plane stress theory for flat panels.

A cut-out in a square panel, particularly if the panel is under shearing load, may reduce the buckling stress considerably. Reinforcement of the hole may increase the compressive and shear buckling stresses to values higher than those for a panel without a hole. The plane stress theory may be used to compute accurately the stress distribution in the neighborhood of a reinforced circular hole loaded by a pin, in a plate of sandwich construction, in which practically all the load is carried by sheets of metal bonded to each other or to a light-weight core.

References

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Revision of Thermocouple Tables

An extensive project is now under way at this Bureau for revision of all the common thermocouple tables in order to take into account the recent changes in electrical units and in the International Temperature Scale. Present plans call for the publication during 1950 of eight tables giving the temperature-emf relations for platinum-platinum rhodium, chromel-alumel, and copper-constantan thermocouples.

The temperature-emf tables for thermocouples previously issued by the Bureau have been widely used in science and industry, not only to convert thermocouple voltages into the equivalent measured temperatures but also in the preparation of purchase specifications for thermocouple wire and in defining the relation between impressed emf and scale reading for pyrometers that indicate temperature directly. Recently, however, in accordance with international agreement, the Bureau adopted the absolute electrical units and began using the definitions of the new International Temperature Scale of 1948 both in its own research program and in calibrating instruments for other laboratories and industries. Revision of the thermocouple tables was then advisable in order to make them consistent with former usage.

In the preparation of the tables, emphasis is being placed on convenience for use. Thus, the explanatory text will be short, the numerals will be as large as practical, and the lay-out of pages and headings will be arranged to facilitate interpolation. The argument will be presented at one-tenth the interval given in the original tables. Inverse tables, formerly lacking, will also be included. Each table, together with its inverse, will be issued as an NBS Miscellaneous Publication and, when announced, will be available from the Superintendent of Documents, U. S. Government Printing Office. The following tables are expected to become available during 1950:

1. Reference table for platinum vs platinum-10% rhodium thermocouples; emf at intervals of 10 microvolts vs degrees C; temperature at intervals of 1 degree C vs microvolts.

2. Reference table for platinum vs platinum-10% rhodium thermocouples; emf at intervals of 10 microvolts vs degrees F; temperature at intervals of 1 degree F vs microvolts.

3. Reference table for platinum vs platinum-13% rhodium thermocouples; emf at intervals of 10 microvolts vs degrees C; temperature at intervals of 1 degree C vs microvolts.

4. Reference table for platinum vs platinum-13% rhodium thermocouples; emf at intervals of 10 microvolts vs degrees F; temperature at intervals of 1 degree F vs microvolts.

5. Reference table for chromel-alumel thermocouples; emf at intervals of 0.1 millivolt vs degrees C; temperature at intervals of 1 degree C vs millivolts.

6. Reference table for chromel-alumel thermocouples; emf at intervals of 0.1 millivolt vs degrees F; temperature at intervals of 1 degree F vs millivolts.

7. Reference table for copper-constantan thermocouples; emf at intervals of 0.1 millivolt vs degrees C; temperature at intervals of 1 degree C vs millivolts.

8. Reference table for copper-constantan thermocouples; emf at intervals of 0.1 millivolt vs degrees F; temperature at intervals of 1 degree F vs millivolts.

The NBS tables for iron-constantan thermocouples will not be revised until completion of an investigation into the properties of some commercially available iron-constantan thermocouples, which is now being carried out by the Bureau in cooperation with the Scientific Apparatus Makers of America.

A limited number of rough-draft advance copies of the first two publications has been prepared to meet interim demand where the need is great. Others will become available in the order listed. Inquiries and suggestions regarding the tables should be addressed to Dr. Robert J. Corruccini, Pyrometry Laboratory, National Bureau of Standards, Washington 25, D. C.

Synthetic Mica

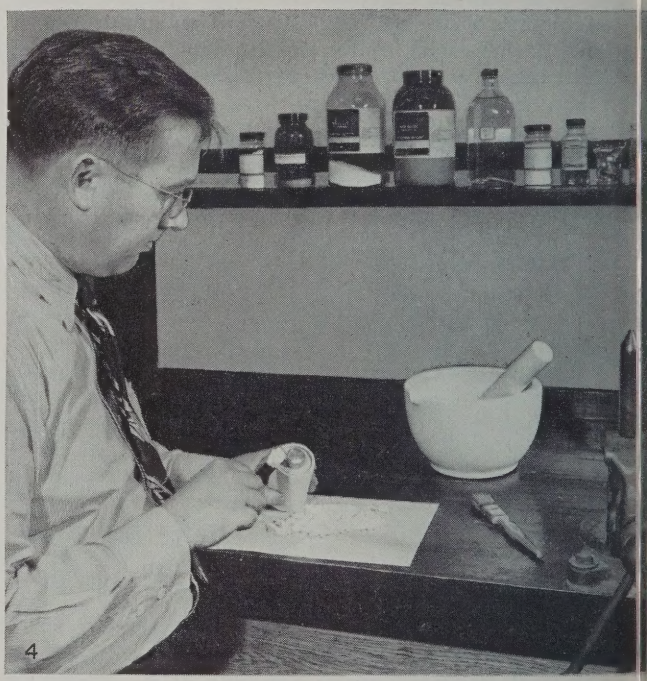
Synthetic mica, with essentially the same properties as natural mica, but able to withstand much higher temperatures, has now been crystallized successfully by Dr. Herbert Insley, Alvin Van Valkenburg, and Robert Pike, at the National Bureau of Standards. This work is part of a broad program of fundamental research on fluorine-type artificial minerals carried on by the National Bureau of Standards under the sponsorship of the Office of Naval Research. The synthetic mica phase of the program has been carried out in cooperation with the U. S. Bureau of Mines and the Colorado School of Mines.

In the Bureau's work on synthetic mica the requirements of eventual quantity production have always been kept in view. Mica could be synthesized by duplicating the conditions under which it is formed in nature, but this would involve extremely high pressures as well as high temperatures. For safety and convenience it is better to work at atmospheric pressure. For that reason the Bureau scientists are using fluorine as a crystallizing agent to grow crystals of mica without using high pressure. Natural fluorine is a gas, poisonous and difficult to control. But a group of synthetic fluorine compounds, the fluorosilicates, provides a convenient way of introducing fluorine into mica synthesis.

The raw materials for making synthetic mica are similar to the raw materials sometimes used in making glass: quartz, magnesite, bauxite, and a fluorosilicate compound (the only unusual ingredient). The raw mixture is placed in a platinum-lined crucible and melted in an electric furnace at a temperature of nearly 1,400° C. As the furnace cools, mica crystals grow from a tiny seed at the bottom of the crucible.

The most satisfactory synthetic mica developed so far has the chemical formula $K_4Mg_{12}Al_3Si_{12}O_{40}F_8$. This is equivalent to a form of natural mica in which the hydroxyl radical has been replaced by fluorine. Impurities may occur in the synthetic mica in the form of milky films parallel to the individual layers or white patches between crystals. Crystals free of impurities are clear and transparent, and thin flakes are easily split away along the planes of natural cleavage. The synthetic form has physical properties that compare favorably with natural mica. Electrical measurements on several clear flakes, $\frac{3}{4}$ inch square by $\frac{1}{32}$ inch thick, indicate a dielectric constant of about 6.3. The largest crystals grown so far at the National Bureau of Standards have a surface area of 4 square inches.

Satisfactory mica synthesis depends to a large extent on the materials used in the crucible lining. Ceramic linings are badly corroded by a fluorine-bearing melt. Carbon and silicon carbide crucibles are somewhat better, but fluoride gases escape through the relatively porous walls, and fine carbon particles become imbedded throughout the synthesized mica. Crucibles lined with platinum foil give the best results. They do not react with the melt and are able to withstand high



1. The raw materials for laboratory production of synthetic mica are first weighed accurately. The mixture consists of four readily available powdered ingredients, 36% silicon dioxide, 13% aluminum oxide, 28% magnesium oxide, and 23% potassium fluorosilicate.

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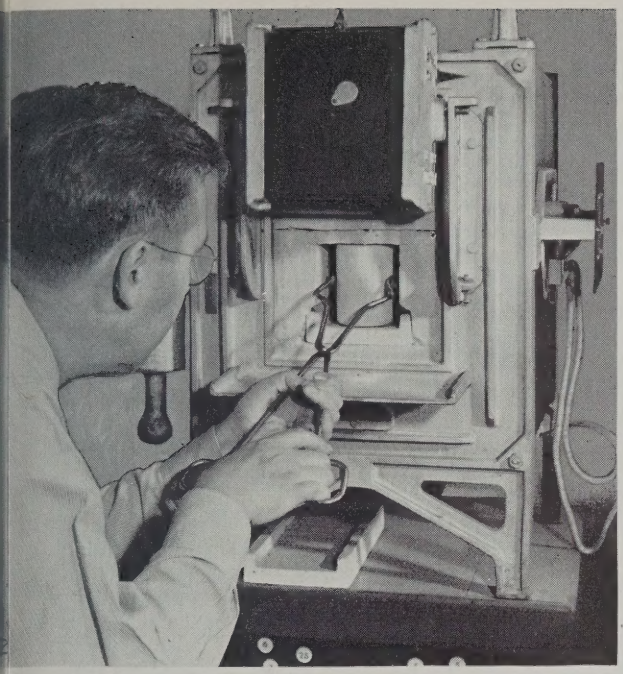
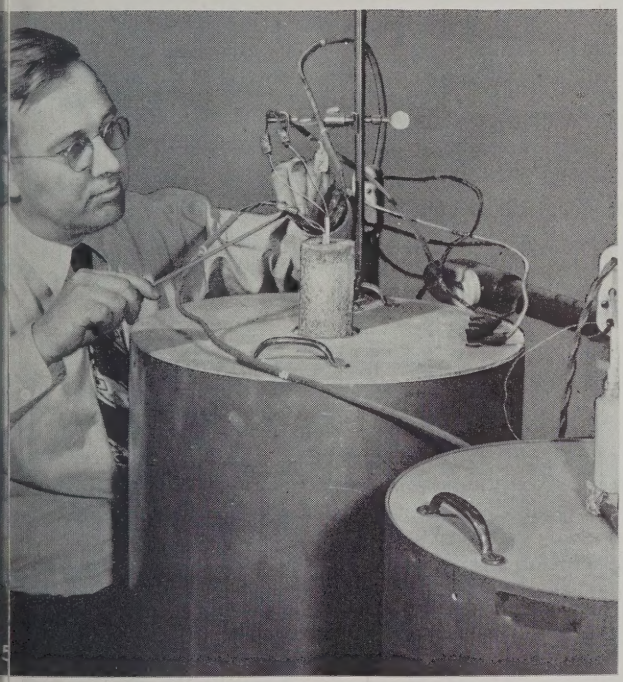
4. The dry ingredients for mica synthesis are then packed into a cylindrical platinum crucible with a cone-shaped bottom. A sand-filled ceramic container is used to support the thin-walled (0.003 inch) platinum. A platinum cover seals the crucible against loss of fluorides.





. After initial mixing, the batch of raw ingredients, ithout the fluorosilicate compound, is placed in a ce- amic crucible and heated for more than an hour in an lectric furnace at a temperature of 1,000° C. This alcining operation drives off carbon dioxide and water.

. The completed charge is lowered into position in a pecial electric furnace and melted at a temperature of early 1,400° C. As the furnace cools, mica crystals row from a seed at the bottom of the crucible. Ther- nocouples trace the thermal history of the process.

3. The calcined ingredients are carefully ground together with the potassium fluorosilicate in a ceramic mortar to obtain uniform mixing. This grinding must be performed quickly to prevent recapture of moisture and carbon dioxide from the air.

6. The small platinum crucibles are carefully stripped away from the crystal mass, which is denser and more compact than the original charge. Individual crystals of synthetic mica are then separated for determination of physical properties.

Flakes of synthetic mica are examined under a binocular microcope to locate any structural defects. Impurities, gas bubbles, faulty orientation, and incomplete crystallization are revealed by this method. Clear crystals are selected for further analysis.

temperatures for long periods. Although initial cost is high, the platinum linings may be melted down and reformed again and again.

The shape of the crucible is also important in mica synthesis. Flat-bottomed crucibles are not desirable because they offer a large surface for the formation of many seed crystals that grow independently in different directions and thus limit the development of single large crystals. Mica has a sheetlike structure and grows faster in a direction parallel to its cleavage plane than in any other direction. Consequently, if a crucible with a cone-shaped bottom is used, the number of seed crystals is reduced and the direction of growth tends to be upward. Experiments are now in progress to find ways of predetermining crystal growth even more completely in order to grow large parallel sheets. The key to this seems to be precise control of temperature differences within the crucible.

Mica's remarkable properties as an electrical insulator have made it invaluable to electrical and electronic industries. The United States is the world's largest consumer of natural mica, but it produces only enough to meet a third of its requirements. During 1948 the United States imported over 10,000 tons of high-grade mica, mostly from India and Brazil, valued at more than 15 million dollars; in the same period, domestic high-grade production totalled only 135 tons with a value of less than 50,000 dollars.

Since the war, world production of natural sheet mica has declined sharply, while production of ground mica has shown a continuing rise to meet the needs of roofing, paint, and rubber industries. The drop in sheet mica output reflects not only decreasing military demands for high-grade mica but also increasing labor costs, which make hand-processing unprofitable. The usable sheet product is only a small fraction of the total processed volume. Some foreign countries can still process natural mica cheaply by hand methods, but producers in the United States are now concentrating on the production of "half-trim" mica.

Successful control of crystal orientation in the growth of synthetic mica would mean that machine methods could be used for large-scale domestic production of sheet mica. In this way mica synthesis could make the United States self-sufficient in high-grade mica insulating materials.

The Ignition Characteristics of Plastics

The increased use of plastics in modern industry and trade has accentuated the need for more accurate data regarding the ignition temperature of various commercial plastics. Procedures or methods used have not always yielded minimum ignition values, information required for the formulation of adequate safety regulations. An investigation of this problem by Nicholas P. Setchkin of the Bureau's fire protection laboratories has resulted in the development of a new method and apparatus for the determination of the "self-ignition" temperature of plastics.[2] Ignition temperatures obtained with this procedure are consistently reproducible within a few degrees and are generally lower than values previously reported. However, with the exception of cellulose nitrate plastic (celluloid), the plastics do not have sufficiently low ignition temperatures to constitute an ignition hazard under ordinary conditions of use.

Two basic physical quantities are significant in the Bureau's method. The first is the "flash-temperature," defined as the lowest temperature at which the amount of combustible gas emitted from a heated sample will be ignited by the external flame. The second is the "self-ignition temperature": that is, the lowest temperature at which oxidation within the plastic mass or its gaseous envelope will liberate enough heat to cause self-ignition. The result is an explosion, a flame, or a sustained glow.

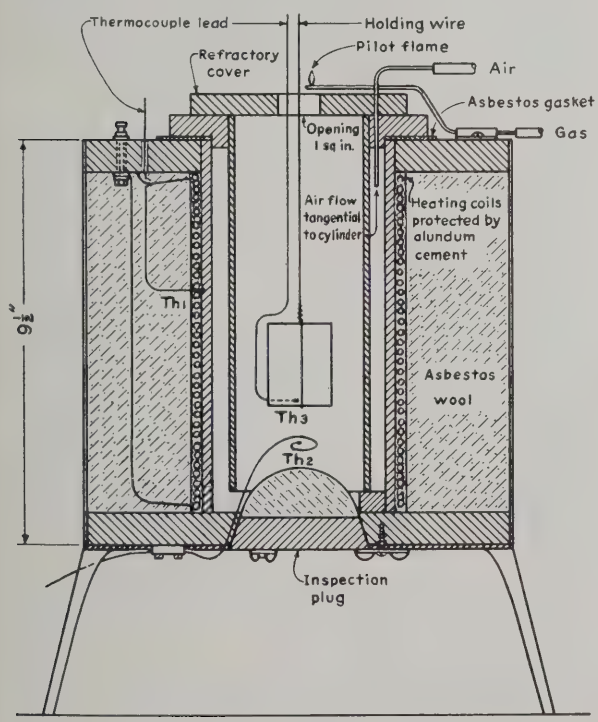
The self-heating of plastics and other organic materials to temperatures far above the temperature of their surroundings is a phenomenon that is often neglected. Solids heated to a temperature above the initial oxidation temperature will self-heat through a reaction with the oxygen in the air. The rate of heat generation depends upon the physical and chemical properties of the materials and the temperature to which the material is initially heated. Dissipation of heat to the surroundings will set an upper limit to the tem-

[2] For further technical details, see A method and apparatus for determining the ignition temperature of plastics. Nicholas P. Setchkin, J. Research NBS 43, 591 (1949) RP2052.

Experiments to determine the ignition temperatures of various plastics show differences between some of them. Cellulose nitrate (top row) remains soft and inflates gradually without self-heating, then suddenly decomposes with a violent flash. Cellulose acetate (second row) also remains soft and forms a number of large bubbles that gradually expand until decomposition takes place. Polystyrene (bottom row) forms a spongy hollow shell that carbonizes until a glow or flame appears.

perature of the oxidizing plastic. The rate of heat dissipation generally depends upon the difference in temperature between the material and its surroundings and upon the coefficient of heat transmission.

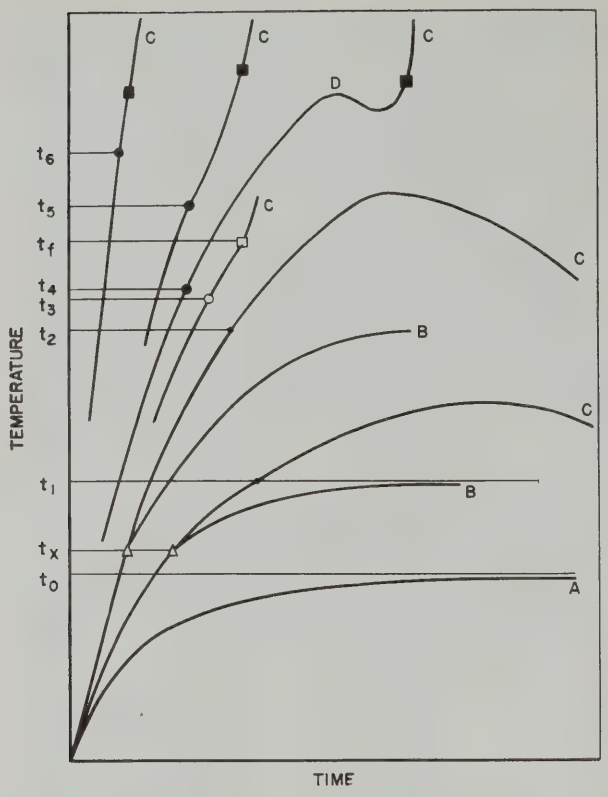
The rate of air flow around the oxidizing material has an important effect on the ignition of plastics and other solid materials. If the velocity of the air flow is too high, the rate of heat dissipation will be increased and the rate of oxidation will be reduced or stopped. In order to overcome such heat losses in ignition-temperature determinations, the rate of heat generation or the initial temperature must be increased. On the other hand, if the rate of air flow is too low, then the air will be contaminated by an excess of decomposition products and the rate of oxidation will be reduced. The air flow should be adjusted to give an optimum rate of temperature rise. Precautions must be taken to maintain the specimens at a fixed position even if they melt. Otherwise, with some plastics, ignition may be observed only at high temperatures where evaporation and evolvement of gas proceed simultaneously with partial melting. Self-ignition may be observed at lower temperatures if such melting plastics are placed in a crucible or a wire-screen cup.



In the Bureau's tests, the behavior of 27 different plastics with different physical properties and ignition characteristics was studied at various temperatures. Each plastic specimen was suspended in the tube of an insulated furnace and the air flow regulated to maintain a constant temperature around the specimen. The hot air elevates the specimen temperature sufficiently to cause self-heating. The specimen then becomes hotter than the surrounding air. Gases emitted from the heating specimen rise to the top of the chamber and at the flash temperature are ignited by the pilot flame.

Operation of the apparatus by the constant-air-temperature method is simple at temperatures up to 800° C. In spite of the constant temperature of the wall, the air temperature around the specimen is very sensitive to the velocity of air flow and to the heat radiated from the specimen during the exothermic reaction. Temperature changes due to air flow can be controlled with an approximately optimum air flow, adjusted for a favor-

A plastic specimen is suspended in the furnace well, and a measured airflow is passed between the heating elements and the specimen. *Th* 1, 2, and 3 are thermocouples in the outer wall, in the airstream, and in the specimen, respectively. The hot air elevates the temperature of the specimen sufficiently to cause self-heating. The specimen then becomes hotter than the surrounding air, and the gasses issuing from it rise to the top of the chamber. At flash temperature the gases are ignited by the pilot flame.



In this graph, the theoretical time-temperature relationship for the heating and ignition of solid materials is plotted. Specimen and furnace temperatures are plotted against reaction time.
△, Temperature of incipient oxidation; □, ignition with igniter; ■; ignition without igniter; ○, flash temperature; ●, self ignition temperature; A, curves of both combustible and incombustible materials; B, curves of incombustible material; C, curves of combustible material; D, the cooling effect of too great or too small airflow over specimen.

able rate of ignition as indicated by the rate of temperature rise.

Flash temperatures were found to range from 141° C for cellulose nitrate to 540° C for phenolic glass-cloth laminate. The self-ignition temperatures of the homogeneous thermoplastic materials ranged from 141° C for cellulose nitrate to 557° C for polyvinyl chloride acetate. These plastics behave in various ways prior to ignition. For example, cellulose nitrate remains soft and inflates gradually without self-heating for a long time, then suddenly decomposes with a violent flash or flame. Cellulose acetate usually self-heats slightly, is also soft and forms a number of large bubbles that gradually expand in the transparent mass until it finally bursts into flame. Vinyl plastics form a spongy hollow shell, which carbonizes until glow or flame appears. Other thermoplastic materials usually melt prior to ignition and produce vapor or gases that ignite in the process of rapid oxidation.

The self-ignition temperatures of thermosetting materials reinforced by cotton, paper, or glass cloths ranged from 430° C for phenolic-paper laminate, to 645° C for melamine-glass-cloth laminate. The ignition of these materials usually occurred from either glow of carbonized parts of the material or self-flash of gases developed from the plastic component.

Results obtained with the Bureau's constant-temperature method are reproducible within two degrees C; values are lower than those usually obtained with other methods. This new technique for determining the ignition characteristics of materials is the first major step in evaluating the ignition properties of a material in terms of the temperature and other controllable conditions. These factors are as important in determining reliable ignition data as they are in obtaining density, conductivity, and other physical properties.

A Reduction-of-Area Gage for Low-Temperature Application

A special reduction-of-area gage, developed by G. W. Geil and N. L. Carwile of the Bureau's thermal metallurgy laboratory, provides with a much higher degree of reliability the essential data for determining some of the mechanical properties of metals and alloys at low temperatures. The need for a gage to follow accurately the change in diameter of a cylindrical specimen submerged in a refrigerant became evident during the Bureau's investigations of the influence of temperature on the properties of metals. For some metals, an accurate determination of the stress-strain curve from yield to maximum load cannot be made from extension measurements—the conventional procedure—because the metal may contract locally before reaching the final maximum load. Simultaneous load and diameter measurements are essential moreover for the determination of the complete true-stress vs true-strain curves for metals tested in tension. With the Bureau's new gage, successive diameter measurements are now possible during the entire deformation of the specimen.[3]

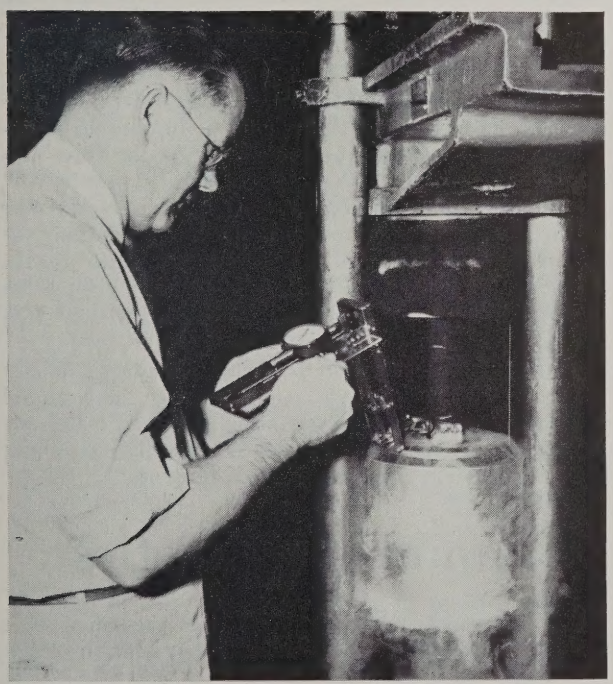
Designed especially for use in tests of metal specimens completely submerged in a temperature-controlled bath ranging from −196° C to +100° C, the gage provides measurements accurate to 0.0001 inch. A careful calibration of the gage using test standards of fused quartz indicates its diameter measurements to be identical, to the nearest one ten-thousandth of an inch, with those made with the optical comparator. True stress-true strain curves for a wide variety of metals,

[3] For further technical details, see A reduction-of-area gage for use at low temperature, G. W. Geil and N. L. Carwile, J. Research NBS **43**, 527 (1949) RP2044; also ASTM Bulletin, Jan. 1950.

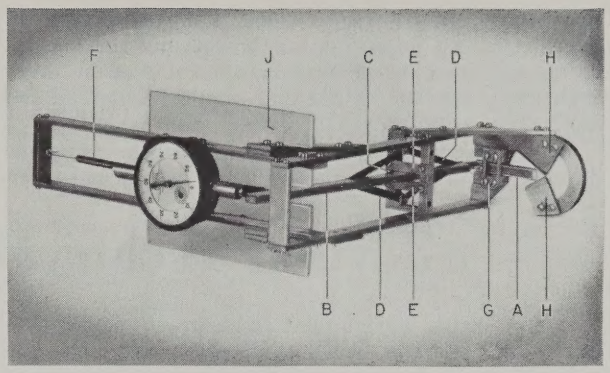
including annealed ingot iron, cold-worked nickel, and cold-worked 18:8 chromium-nickel steel, have shown its performance to be very satisfactory.

The reduction-of-area gage consists essentially of one sliding and two fixed anvils connected through a lever mechanism to a dial gage. This arrangement is such that when the specimen is placed between the three anvils, any slight movement in the sliding anvil due to a change in the specimen will be accurately registered on the dial gage. The anvils are made of SAE 52100 steel and the lever and pivot knife edge of AISI type 440C stainless steel, heat treated for hardness values of Rockwell C63 and C55, respectively. The framework of the instrument is constructed of cold-rolled Monel, which has suitable corrosion resistance and strength.

During a tension test the change in diameter of the test specimen is followed by the movement of the sliding anvil, which is held against the specimen with slight pressure exerted by a tension spring. The movement of this anvil is transmitted to the spindle of the dial indicator by means of a simple lever whose pivot or fulcrum is a knife edge. To maintain the lever in position, it is supported by four flexure strips. A lubricated bearing of the roller, ball, or sleeve type cannot be used as the fulcrum for the lever because this portion of the instrument is submerged in the temperature-controlled liquid bath.



The reduction-of-area gage is being used by G. W. Geil to measure a specimen submerged in a bath of liquid air. The specimen is under compression in a 50,000 lb capacity testing head. The lower threaded end of the specimen extends through the bottom of the cylindrical vessel containing the refrigerant and into the lower adapter of the testing machine. Lead washers seal against loss of the liquid air.



This reduction-of-area gage accurately measures diameter changes in cylindrical metal specimens under tension at very low temperatures. The gage was designed to overcome difficulties usually encountered while measuring metals submerged in refrigerants at temperatures as low as —196° C. *A*, sliding anvil; *B*, lever; *C*, pivot; *D*, flexure strips; *E*, guide bars; *F*, tension spring; *G*, retainer caps; *H*, fixed anvils; *J*, shield.

The sliding anvil is attached to the lever arm with a small tension spring to facilitate installation of the gage on the tensile specimen while immersed in the liquid bath. Six ribs on the anvil serve as the bearing surfaces. Both ends of this anvil and the contact ends of the fixed anvils are machined to a dihedral angle of 50° and a radius of 0.02 inch. This design assures free access of the measuring contact edges of the anvils to the minimum-diameter portion of the tensile specimen.

The contact edges of the anvils are coplanar and at an angle of 60° to each other. With this arrangement, the movement of the sliding anvil is 1.5 times the change in diameter of the test specimen. The length of the lever arm between the pivot knife edge and the anvil knife edge is approximately 2.5 inches; the length of the lever arm between the pivot knife edge and the contact point of the dial indicator is approximately 5 inches. Thus the total magnification of the instrument is approximately 3 (2.985 by actual calibration).

The dial indicator is a jeweled low-friction type and is mounted on the framework so that it is adjustable. Its range is selected to conform to the ductility of the metal being tested.

The manipulation of the new gage to determine the change in diameter of an unnotched cylindrical specimen during a tension test at low or moderately elevated temperatures is very simple. The test specimen, supported vertically between the adapters of the tensile testing machine, is completely submerged in the temperature-controlled liquid bath. The gage is placed in position on the specimen with the measuring anvils at any position along the gage length of the specimen, and a time interval of about 15 minutes is allowed for the gage to come to temperature equilibrium. The alinement of the gage with respect to the specimen is adjusted until a minimum-diameter reading is obtained, indicating that the plane of the measuring anvils is perpendicular to the axis of the specimen. While

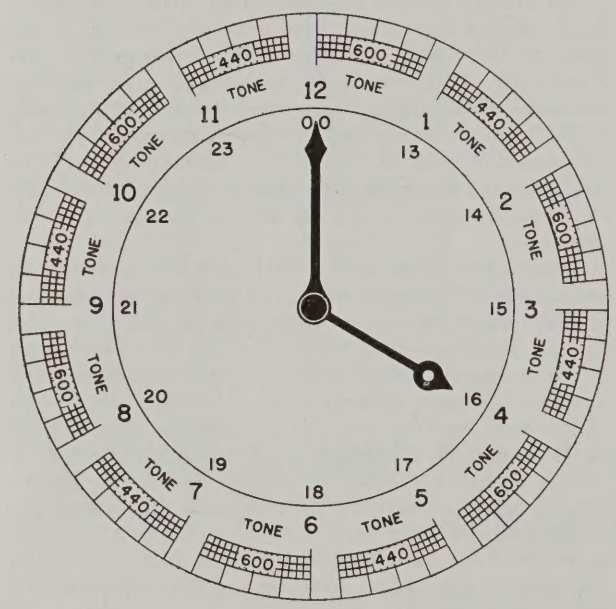
maintaining this alinement, the gage, supported by hand, is moved up and down through the gage length of the test specimen to find the diameter at the minimum cross section. Numerous simultaneous load and diameter readings are made during the tension test.

The gage can also be used to follow the change in diameter of circumferentially notched cylindrical specimens during test in tension at low or moderately elevated temperatures. For this purpose a set of anvils whose measuring edges are machined to an angle less than the smallest notch angle of the test specimens is required. The radius of the measuring edges of the anvils likewise must be less than the smallest radius at the root of the notch.

Revised Technical Broadcast Services

A new series of technical radio broadcast services over radio stations WWV, Beltsville, Maryland, and WWVH, Maui, Territory of Hawaii, was inaugurated on January 1, 1950. Except in certain details, these services of the National Bureau of Standards will not differ greatly from those given in the past.

The revised services from WWV include (1) standard radio frequencies of 2.5, 5, 10, 15, 20, 25, 30, and 35 megacycles; (2) time announcements at 5-minute intervals by voice and International Morse Code; (3) standard time intervals of 1 second, and 1, 4, and 5 minutes; (4) standard audio frequencies of 440 cycles (the standard musical pitch A above middle C) and 600 cycles; (5) radio propagation disturbance warnings by International Morse code consisting of the letters W, U, or N, indicating warning, unstable conditions, or normal, respectively.



Signal sequence from WWV and WWVH.

The audio frequencies are interrupted at precisely 1 minute before the hour and are resumed precisely on the hour and each 5 minutes thereafter. Code announcements are in Universal Time using the 24-hour system beginning with 0000 at midnight; voice announcements are in Eastern Standard Time. The audio frequencies are transmitted alternately: The 600-cycle tone starts precisely on the hour and every 10 minutes thereafter, continuing for 4 minutes; the 440-cycle tone starts precisely 5 minutes after the hour and every 10 minutes thereafter, continuing for 4 minutes. Each carrier frequency is modulated by a seconds pulse which is heard as a faint tick; the pulse at the beginning of the last second of each minute is omitted.

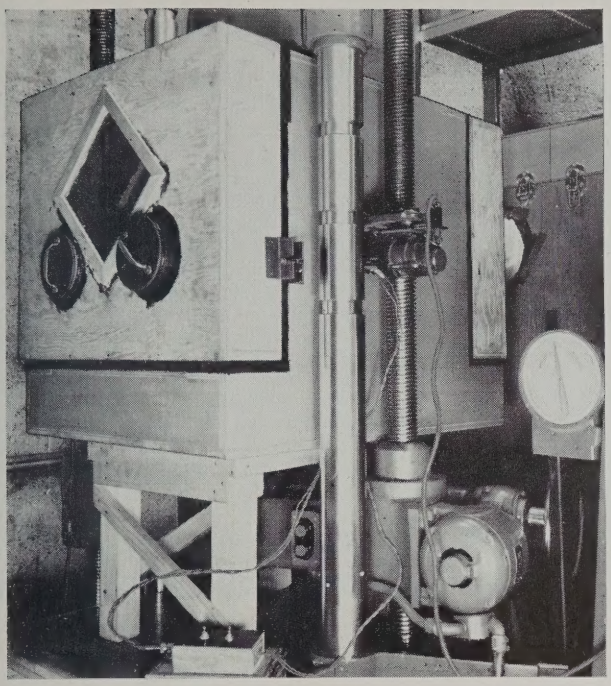
Radio station WWVH, recently established in Hawaii by the National Bureau of Standards, broadcasts on an experimental basis on 5, 10, and 15 megacycles. The program of broadcasts on the three frequencies is essentially the same as that of station WWV. Reception reports indicate that WWVH is received at many locations not served by WWV, thus extending the area served by standard frequencies and time signals. Time announcements in Universal Time are given from WWVH every 5 minutes by International Morse Code only.

Further information on the technical radio broadcast services may be obtained on request from the National Bureau of Standards, Washington 25, D. C. Reports on reception are welcomed; forms on which to submit such reports may also be obtained on request.

Mechanical Properties of Laminated Plastics

Laminated plastics are made of sheets of paper or fabric impregnated with resins and bonded together by heat and pressure. Their outstanding properties are low density, high impact strength, and low thermal and electrical conductivities. Such laminates have been used extensively for more than 35 years as electrical insulation. Currently, widespread application of plastic laminates to the refrigerator and home freezer industry has resulted from their high impact strengths at low temperatures and their low thermal conductivity. The light weight and high strength of these materials have also brought about increasing application in aircraft, especially for the fabrication of accessories and semistructural parts such as radomes, floors, bulkheads, propellers, wing flaps, and ducts. In these more recent uses the laminates are subjected to a wide range of temperature, and little or no information has been available on their mechanical properties at high and low temperatures.

To provide such information, the mechanical prop-



Low- and high-temperature tensile tests of laminated plastics were made in a temperature-controlled cabinet (upper left). The cabinet is shown in place in a hydraulic-type testing machine. A triple-paned window and two large armholes in the front of the enclosure permit convenient handling of the specimens and equipment. The Selsyn motor links the tensile strain gage to the stress-strain recorder.

erties of eight representative laminated plastics were evaluated [4] at the extreme temperatures of use by J. J. Lamb, Isabelle Albrecht, and B. M. Axilrod of the Bureau's plastics laboratory in a project sponsored by the National Advisory Committee for Aeronautics. Izod [5] impact strengths; flexural, tensile, and compressive strengths; and elastic moduli were measured at −70°, 77°, and 200° F. One of the laminates studied was made of a polyester resin with glass-fabric reinforcement, while the others were of phenolic resins reinforced with asbestos fabric, paper, cotton fabric, and rayon fabric.

This work was part of the Bureau's continuing program on the properties of plastic laminates, which has included the effect of simulated service conditions [6] on such materials and the resistance of laminates to fuel immersion. Other projects now under way deal with the resistance of glass-fabric laminates to high temperatures (up to 600° F), the effect of low-temperature storage on impact strength, and the influence of production variables in the manufacture of glass-fabric laminates on the properties of the finished sheets.

The tests of mechanical properties were carried out in thermally insulated enclosures built especially for this purpose. Special jigs and fixtures were also required for the flexural and compression tests. For the impact tests, a Baldwin-Southwark pendulum-type Izod impact machine was used. The flexural, tensile, and compressive tests employed two Baldwin-Southwark hydraulic universal testing machines located in a room in which the atmosphere was controlled at 77° F and 50 percent relative humidity.

The tensile strengths of the high-strength-paper, rayon-fabric, and glass-fabric laminates were found to be about three times those of the cotton-fabric and asbestos-fabric phenolics. In compressive strength the glass-fabric laminate was outstanding; at 77° F its strength in the crosswise and lengthwise directions was 36,000 and 42,000 lb/in.^{2}, respectively. The compressive strengths of the other laminates were about 21,000 lb/in.^{2}

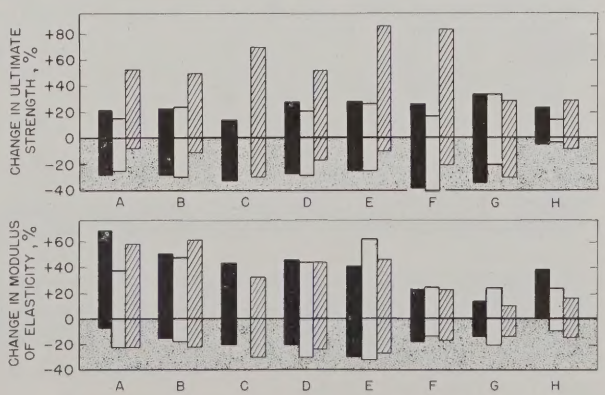
It was found that the tensile and compressive strengths and moduli of elasticity of all the laminates increased at low temperature and decreased at high temperature. Thus, for all laminates except the asbestos-fabric product, the tensile and compressive strengths at 200° F were approximately half of the corresponding values at −70° F. In the case of the asbestos-fabric product, the changes in the strength values were much smaller.

The decrease in the tensile and compressive moduli of the samples with temperature was much greater from −70° to 77° F than from 77° to 200° F. Except for the high-strength-paper material, the over-all changes were greater for the cellulose than for the mineral-type

[4] For further technical details, see Mechanical properties of laminated plastics at −70°, 77°, and 200° F, by John J. Lamb, Isabelle Albrecht, and Benjamin M. Axilrod, J. Research NBS **43**, 257 (1949) RP2028.

[5] The Izod impact test is made with a pendulum-type testing machine on a specimen in which a notch has been cut in order to localize fracture and to restrict plastic deformation.

[6] Effect of simulated service conditions on plastics, NBS Technical News Bulletin **33**, 108 (1949).



Changes in strength and elasticity of plastic laminates with temperature are indicated by the blocks above and below the zero lines. Those above the lines represent relative magnitudes of the changes when the temperature was raised from 77° to 200° F; those below, the corresponding changes when the temperature was lowered from 77° to −70° F. Solid blocks are flexural properties; white, tensile; and shaded, compressive. *A* is a low-pressure cotton-fabric phenolic laminate; *B*, low-pressure Grade C phenolic; *C*, Grade C phenolic; *D*, high-pressure Grade C phenolic; *E*, rayon-cotton-fabric phenolic; *F*, high-strength phenolic; *G*, glass-fabric unsaturated polyester; *H*, asbestos-fabric phenolic.

laminates. In general, the high-strength-paper, asbestos-fabric, and glass-fabric products showed about the same variation of tensile and compressive moduli with temperature.

The Izod impact strength values for the rayon-fabric and the glass-fabric laminates were much greater than for the other materials. It was also evident that the variation in impact strength with temperature was different for plastics having different types of reinforcement. While the glass-fabric laminates decreased steadily in impact strength with increasing temperature, the cotton-fabric laminates exhibited increasing impact strength with temperature, roughly doubling their strength values between −70° and 200° F. On the other hand, the asbestos-fabric, rayon-fabric, and high-strength-paper laminates showed little variation in impact strength between −70° and 200° F.

In flexural properties the high-strength-paper and glass-fabric laminates were superior. An increase in flexural strength was noted for all the samples at low temperature; at high temperature a decrease occurred for all except the asbestos-fabric laminate, which showed no change.

The results of the Bureau's study indicate that the flexural properties of plastic laminates at high temperature are not a function of temperature only, but may be affected by further cure of the resin and loss of moisture content. It was also apparent that the effect of high humidity in addition to an elevated temperature may be quite different from the effect of temperature alone. Thus, a severe loss in strength was noted for the high-strength-paper and one low-pressure cotton-fabric laminate at 150° F when the humidity was increased to 90 percent.

NBS Publications

Periodicals [7]

Journal of Research of the National Bureau of Standards, volume **44**, number 1, January 1950. (RP2053 to RP2061, inclusive).

Technical News Bulletin, volume **34**, number 1, January 1950. 10 cents.

CRPL–D65. Basic Radio Propagation Predictions for April 1950. Three months in advance. Issued January 1950. 10 cents.

Nonperiodical [7]

Research Papers [7 8]

RP2042. The freezing point of uranium. Andrew I. Dahl and Harold E. Cleaves. 5 cents.

RP2043. Dissociation constants of weak bases from electromotive-force measurements of solutions of partially hydrolized salts. Roger G. Bates and Gladys D. Pinching. 5 cents.

RP2044. A reduction-of-area gage for use at low temperatures. Glenn W. Geil and Nesbit L. Carwile. 5 cents.

RP2045. Mass spectra of C_5H_8 isomers. Fred L. Mohler, Evelyn G. Bloom, Laura Williamson, C. E. Wise, and E. J. Wells. 5 cents.

RP2046. A note on the numerical integration of differential equations. W. E. Milne. 5 cents.

RP2047. Measurement of the disintegration rate of sodium [22] by the coincidence method. J. L. Herson. 5 cents.

RP2048. Submicroscopic structure of cellulose from nitrogen sorption measurements. Charles M. Hunt, Raymond L. Blaine, and John W. Rowen. 5 cents.

RP2049. Vapor pressures and boiling points of sixty API-NBS hydrocarbons. Alphonse F. Forziati, William R. Norris, and Frederick D. Rossini. 10 cents.

RP2050. Bond of concrete reinforcing bar. Arthur P. Clark. 10 cents.

RP2051. Analysis of the direct-current bolometer bridge. David M. Kerns. 10 cents.

RP2052. A method and apparatus for determining the ignition characteristics of plastics. Nicholas P. Setchkin. 15 cents.

Commercial Standards [7]

CS20–49. Vitreous china plumbing fixtures. (Supersedes CS20–47.) 15 cents.

CS90–49. Power cranes and shovels. 15 cents.

Articles by Bureau Staff Members in Outside Publications [9]

Correlation of coronal and geomagnetic observations. 1944–1946. J. Virginia Lincoln and A. H. Shapley. Trans. Am. Geophysical Union (1530 P Street, NW., Washington 5, D. C.) **29**, 849 (1948).

Correlations in measurements on superfluidity in liquid helium II. J. R. Pellam. Phys. Rev. (57 East Fifty-fifth Street, New York 22, N. Y.) **76**, 158 (1949).

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Experiments in chromium electrodeposition with radioactive chromium. Fielding Ogburn and Abner Brenner. J. Electrochem. Soc. (235 West 102d Street, New York 25, N. Y.) **96**, 347 (1949).

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Simplified technique for surface area determination by adsorption of nitrogen. W. V. Loebenstein and V. R. Deitz. J. Chem. Physics (57 East Fifty-fifth Street, New York 22, N. Y.) **17**, 1004 (1949).

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